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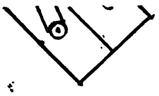


THE FIRST PRINCIPLES
OF
PERSPECTIVE,
EXPLAINED
THEORETICALLY AND PRACTICALLY,
IN A
Course of Easy Studies,
DESIGNED FOR
SELF TUITION AND THE USE OF TEACHERS.

BIBLIOTHECA BODLEIANA

BY
FELIX DUFFIN.

LONDON:
E. & F. N. SPON, 16, BUCKLERSBURY.

1853

LONDON:
LEWIS AND SON, FINCH-LANE, CORNHILL.

INTRODUCTION.

In connection with the artist, the engineer, the builder, or the artizan, the utility of a well-grounded knowledge on the subject "Perspective" has been sufficiently admitted, representations of objects as they would appear if constructed, being often required before the objects in question can be produced; also, to assist the judgment respecting a choice from different designs, or to explain to others the nature of an idea, or of an invention originated in the mind, in either case that drawing which most nearly represents the natural appearance of an object is most elucidatory.

The plea of expedience in reference to the representation of objects as they are not, or cannot appear, is evidently an absurdity; such a method of explanation is well calculated to mislead those on whom it is urged; on the contrary, when an object is represented as it appears, the drawing addresses itself truthfully, and with equal force, to the scientific as well as to the comparatively uninformed observer.

To many, at first sight, the study of perspective has appeared so much enveloped in mystery that the idea of progress therein in the only manner likely to afford a feeling of satisfaction has been abandoned at the outset, owing to the dread of difficulty, while, in point of fact, the principles of the science are theoretically simple, their application practically, of great utility in the ordinary intercourse of life, and certainly most elegant adaptations of mathematical science.

It has been remarked that a knowledge of some geometrical propositions may be gained during the course of practical operation required for the construction of the figures; in like manner it has been supposed that the elementary operation necessary to the acquirement here proposed may be successfully applied,—since the figures may be mechanically drawn in the first instance according to the instructions given, affording subsequent matter for reflection either in connection with the explanatory text or otherwise.

Works on the subject have frequently been considered obscure, and though some very useful treatises are extant, such are in most cases too expensive to attain general circulation. In the instance of tuition by professors, some difficulty has been experienced, owing to the want of a simple yet thoroughly scientific mode of procedure.

Although the method submitted be calculated to facilitate self instruction, it cannot be denied that much advantage may be derived from the assistance of a qualified teacher, to whom it is presumed the following work may be deemed of utility, the principal elementary operations of the art being herein concisely contained, with progressive steps, which, being strictly adhered to, the excursive practice frequently originating in mere curiosity will not retard progress.

In the following studies an attempt has been made to subject the first principles of perspective to a strict analysis, also to exhibit, in a compendious form, the elementary practice by which the art of projecting representations of certain geometrical solids, under various conditions, may with ease be scientifically demonstrated and explained to persons previously unacquainted with mathematical science.

The student, having mastered the essential principles so far that the conditions of the ground plans may be varied at pleasure from those of the examples submitted—and the projections corresponding to such altered conditions readily produced, may be said to have acquired a practical acquaintance with the subject, the possession of which would to many prove a source of satisfaction and confidence. The theory and practice necessarily combined with that amount of qualification being capable of universal application; such also constituting the first and great step to a familiar acquaintance with the simple and elegant science "Perspective."

FELIX DUFFIN,
Teacher of Perspective, Drawing, and Painting.

2, Cardigan Place,
New North Road, Hoxton.
September, 1853.

The Author of this treatise will undertake to teach thoroughly, and without difficulty, the elements of Perspective in a course of eight lessons; and is open to engagements respecting Military and other Geometrical Draughting; Drawing of the Human Figure Anatomically, or from the Antique; also, Landscape Painting, in Oil, or Water.

THE NATURE OF

PERSPECTIVE PROJECTION.

Objects are seen by means of rays of *natural* light proceeding from the sun, or *artificial*, from a candle or lamp; rays falling upon an object are reflected to the eye.

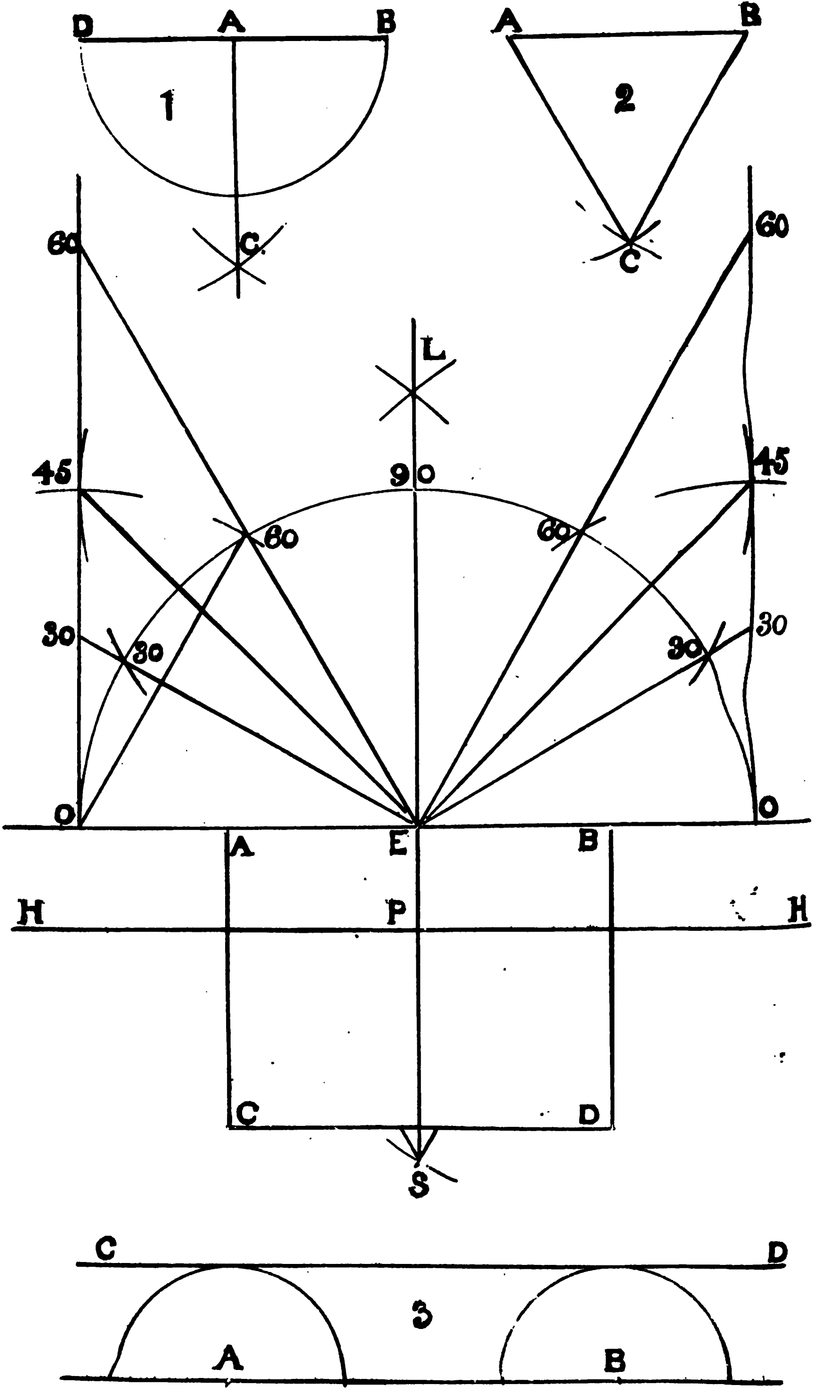
ERRATUM.

Page 27, lines 3 and 4, read, *distance* into the picture of angle, F, 20 feet.

the actual position of the object, the representation of such object would be correctly produced.

The following studies are geometrical demonstrations of the methods whereby the said points are found upon the plane of the perspective, and may be easily explained; but the perspective of colour must in a great measure depend on individual qualifications, natural and acquired.

Pl.1.



STUDY No. I.—See Plate 1.

TEN GEOMETRICAL PROBLEMS.

Problem 1.—*To let fall a perpendicular from a given point on a line, fig.* 1. *Euclid, book* 1*st, proposition* 11*th.*

Operation 1st. Draw the line D, B. Let the given point be at A.—Op. 2. Take in the compasses the extent A, B, and with one foot at A, describe the semicircle.—Op. 3. With a greater extent in the compasses, and one foot first at D, and next at B, find the point of intersection C.—Op. 4. Through C draw the perpendicular A, C.

Prob. 2.—*To form an equilateral triangle upon a given line. Eu. b.* 1, *p.* 1.

Suppose on the line A, B, fig. 2.—Op. 1. Take in the compasses the line A, B, and with one foot first at A, and next at B, find the point of intersection C.—Op. 2. Draw the lines A, C, B, C.

Prob. 3—*To draw a parallel to a given line. Eu. b.* 1, *ps.* 31 *and* 33*; b.* 3, *p.* 23.

Suppose to the line A, B, fig. 3.—Op. 1. From a point on the line A, B, as A, describe a semicircle.—Op. 2. With the same extent in the compasses, and on the line A, B, describe a semicircle from a point, as B.—Op. 3. Draw the line C, D, touching the semicircles.

Prob. 4.—*To draw the plane of the perspective A, B, C, D; (that is the surface on which the picture is to be drawn) to a given scale: (in this instance two inches wide, by one and a half in height.) Eu. b.* 5*; definitions* 1, 2, *and* 3*; study, No.* 1.

Op. 1. Draw the line of projection O, O.—Op. 2. Take in the compasses from a scale one inch, and from the centre E set off both ways on the line of projection one inch, viz., to A, and also to B.—Op. 3. Let fall the perpendiculars A, C, and B, D. (See Prob. 1).—Op. 4. Set off on those from A and B the dimension one and a half inch, that is, A, C and B, D. (Eu. b. 1, ps. 2 and 3).—Op. 5. Draw the ground line through C, and D.

Prob. 5.—*To draw the given angle (in this instance one of* 60 *degrees), under which the plane of the perspective A, B, C, D, is seen. Study, No.* 1. *Eu. b.* 4, *p.* 15 *; b.* 1, *ps.* 1 *and* 8 *; b.* 6, *p.* 5 *; b.* 11, *p.* 10.

Op. Take in the compasses the line A, B; and first with one foot at A, and next at B, describe the intersecting arcs to find the point S. (See Fig. 2, Prob. 2.

Note.—S is the station point; and E, S, is the distance of the spectator's eye from the plane of the perspective A, B, C, D.

Prob. 6.—*To determine the height of the eye upon, or opposite to, the plane of the perspective, (in this instance one inch above the level of the ground line C, D.) Eu. b.* 11 *; definitions* 3 *and* 4 *; also p.* 3.

Op. 1. Take in the compasses the height of the eye, one inch, and set that extent off upward on the line C A, from C; and also on the line D, B, from D.—Op. 2. Through the points so found draw the line of the horizon H, H; which determines the height of the spectator's eye above the ground level.

Note.—The eye might be represented at any height on the plane of the perspective at pleasure, according to the position of the horizontal line H, H.

Prob. 7.—*To find the point of sight. Eu. b.* 11 *; defs.* 3, 4 *; ps.* 3, 7, 13, 14, 15, 16, 18, 38.

Op. From S to E draw the vertical line S, E, the intersection of which with the line of the horizon, determines the position of the point of sight P.

Note.—The point of sight is in every case exactly opposite to the eye of the spectator upon the plane of the perspective.

PROB. 8.—*To describe a semicircle to radius distance of the eye; and also tangent lines to the semicircle. Eu. b.* 4*; p.* 15*; b.* 1*; p.* 11*; b.* 3*; def.* 2*; ps.* 16, 17, 18*; b.* 4*; p.* 7.

OP. 1. Take in the compasses the extent S, E; (the distance of the eye from the picture,) and with one foot at E, describe the semicircle 0, 90, 0 (the distance of the eye is thus made radius). *To raise a perpendicular from a given point on a line. Eu. b.* 1*; p.* 11.

OP. 2. With a greater extent in the compasses, and one foot in 0, both on the right and left of the semicircle, find the point of intersection L.—OP. 3. Draw the perpendicular E, L, through L. (This operation is the reverse of Prob. 1, Fig. 1.)—OP. 4. Draw parallels to E, L; viz., 0, 60.—0, 60. (See Fig. 3.) The lines 0, 60,—0, 60, are tangent lines to the semicircle 0, 90, 0; since they touch the semicircle each respectively at 0 on the right and left hand.—Eu. b. 3; p. 18.

PROB. 9.—*To trisect a quadrant, or an angle of* 90 *degrees, (in this instance it will be necessary to trisect both quadrants,) thus dividing the arch of the semicircle into six equal parts. Eu. b.* 4*; p.* 15.

OP. 1. Take in the compasses the extent E, O, (radius), and with one foot at O on the one hand, find on the arch of the semicircle the point 60.—OP. 2. Repeat the process on the other hand to find the angle of 60 degrees on that side.—OP. 3. With the same extent in the compasses, and one foot at 90, find on the arch the points 30,—30.

NOTE.—The semicircle 0, 90, 0, is supposed to contain 180 degrees or divisions of equal parts; half the semicircle, viz., the arc, 90, 0, is called a quadrant, it being equal to one-fourth of a circle; and is thus supposed to contain 90 of the equal parts or divisions which the whole arch 0, 90, 0, is supposed to contain; 0, 60, on the arch being equal to two-thirds of the quadrant, contains therefore in supposition 60 degrees; 0, 30, being equal to one-third of the quadrant arch, contains the measure of 30 degrees; the semicircle is thus divided into six equal parts.

PROB. 10.—*To construct a line of tangents to a given radius* (*the radius given in this instance is S, E,—the distance of the eye from the picture*).

To obtain tangents to the angles of 45 *degrees.*

OP. 1. Take in the compasses the extent E, S; (radius), and with one foot at O, both on the right and left hand, find on the tangent lines the points 45,—45.—OP. 2. Draw lines from E to 45,—45. 0,45;—0,45; are tangents to the angles of 45 degrees, O, E, 45;—O, E, 45; and are each equal to the radius given, viz., S, E, or to E, O.—Eu. b. 1, p. 46; b. 4, ps. 7 and 8.

To obtain tangents to the angles of 60 *degrees.*

OP. 3. Draw lines from E through the divisions of the arch marked 60,—60, until those meet with or cut the tangent lines. 0, 60,—0, 60, thereon are tangents to the angles of 60 degrees.

NOTE 1.—The oblique right (or straight) line 0, 60, is equal to E, S;—E. 0; or E, 90: in other words, the chord of 60 degrees is equal to radius; and consequently to the tangent of 45 degrees.—Eu. b. 4, p. 15.

To obtain tangents to the angles of 30 *degrees.*

OP. 4. Draw lines from E through the divisions of the arch marked 30,—30, until those lines meet with or cut the tangent lines. 0, 30,—0, 30, thereon are tangents to the angles of 30 degrees.

NOTE 2.—By dividing the arch of the quadrant still further, and drawing lines through the points of division until those lines meet with or cut the tangent lines, angles may be found, and their corresponding tangents to an extent; but it is evident there can be no tangent to the angle of 90 degrees, the line E, 90, and the tangent lines E, 60,—E, 60, being parallels.—Eu. b. 1, ps. 9, 23, 25.

NOTE 3.—In all cases the radius of the semicircle 0, 90, 0, must be strictly in agreement with the distance of the eye E, S.—Eu. b. 4, p. 15. And if the dimensions of the perspective plane A,B,C,D, be increased or diminished, every line shown in the foregoing elementary study (No. 1) must be increased or diminished in exact proportion; and in accordance with the order observed in the given directions.

NOTE 4.—By means of lines radiating from the point E, the required angles with the picture (or which is the same in effect with the line of projection O, O,) of squares, or other rectangular plans may readily be found. (See Studies 4, 5, 6, 7, &c.) And the use of a tangent line involves a practical method for finding the vanishing point on the horizon of a line inclined at any given angle to the picture. (See also Studies 4, 5, 6, and others in which the foregoing elementary operations and references forming the groundwork are rendered subservient to practical perspective.—Eu. b. 11, ps. 1, 3, 4, 7, 8, 10, 13, 14, 15, 38.

Removal of the Station Point.

EXAMPLE 1, fig. 1, (folding plate). Here the point of sight is at P, to the left of the central position; the spectator, in supposition, having moved to the left of the former station point; the vertical line, E, S, (always accompanying the eye) is supposed to be the base, at the perspective plane, of a vertical plane passing through the eye of the observer.

Example 2, fig. 2, (folding plate). Here the spectator is supposed to have moved to the right of the centre, and, as in Ex. 1, the picture is, in supposition, seen under an oblique angle.

NOTE.—The station point may be thus removed to any convenient distance on the right or left of the central position.

Example 3, fig. 3, (folding plate). In this example, the spectator is supposed to have removed backward, or from the perspective plane, to twice the distance given in the previous instances; consequently, the plane of the perspective, A, B, C, D, is supposed to be seen (obliquely) under an angle of 30 degrees only; the visual angle diminishing as the distance of the eye from the picture is increased.

STUDY No. II.—Plate 2.

1st. *Plan of* 64 *Squares at or touching the plane of the picture, and parallel thereto.*

2nd. *The same projected perspectively under the following conditions:—*

Dimension of each square, one quarter of an inch to the side.
Dimensions of the picture, two inches by one and a half inch.
Visual angle of the picture, 60 *degrees.*
Height of the eye above the ground level, one inch.
Position of the point of sight, midway on the horizontal line.

The ground plan, Study No. 2, is a square, A, G, K, B, of two inches to the side, containing 64 squares, each measuring one quarter of an inch to the side.

Operation 1. Draw the preparatory figure according to the direction given in Study No. 1, viz.:—

1st. The Plane of the Perspective, A, B, C, D.—Prob. 4.

2nd. The angle under which it is seen, A, S, B, of 60 degrees. —Prob. 5.

3rd. The line of the horizon, H, H.—Prob. 6.

4th. The vertical line, S, E.—Prob. 7.

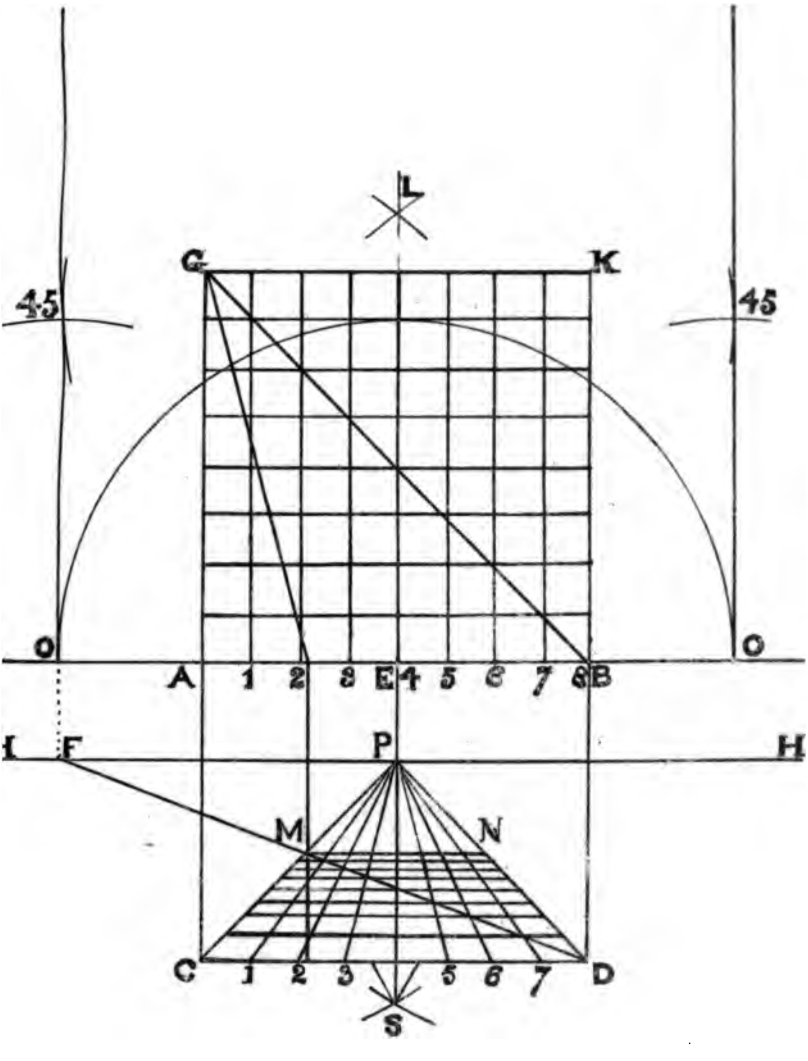
5th. The semicircle, 0, 90, 0, to radius, S, E.—(Distance of the eye).—Prob. 8.

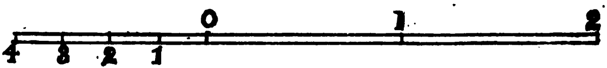
6th. Raise the perpendicular, E, L.—Prob. 8, Ops. 2 and 3.

7th. Draw tangent lines, parallel thereto, 0, 45 ; 0, 45.—Prob. 8. Op. 4.

8th. Set up the tangents, 0, 45; 0, 45, (each equal to the radius, S, E.—Prob. 10, Op. 1.

Pl. 2.





To draw the ground plan.

Op. 1. Continue the line C, A, to G, and D, B, to K; or raise a perpendicular from A, and also from B, and set off with the compasses on those lines the distance A, B; (thus finding the points G, and K —Op. 2. Draw G, K. A, B, is divided into two equal parts at E.—Op. 3. Take in the compasses half an inch, and divide A, E, into two equal parts, as at 2, also E, B, as at 6.—Op. 4. Take in the compasses one quarter of an inch, and divide A, 2, as at 1; 2, 4, as at 3; 4, 6, as at 5; and 6, 8, as at 7.—Op. 5. By the same method divide the lines G, K; A, G; B, K; draw the perpendiculars from A, B, to G, K; also the horizontal lines from A, G, to B, K, thus the square of two inches to the side will be divided into 64 squares, each of one quarter of an inch to the side.—Op. 6. Draw the diagonal B, G; a portion of which, if the plan be drawn correctly, will be a diagonal to each of the smaller squares through which it passes.

Practical Example.—A plan reduced by scale, in geometrical ratio.

Plans of objects for the sake of convenience are generally drawn to a reduced scale, that is to say, smaller than the original object. The foregoing is a plan of 64 squares similar to those of a chess board, which may be drawn or projected in strict accordance with the scale of the original, in other words to the same size; or in such proportion to the original object as may be convenient; for instance, in this case, each of those squares measuring one quarter of an inch to the side may represent one square inch;—that is to say, a square measuring one inch to the side; or it may represent one square foot, or other square dimension at pleasure. Thus if the plan of a chess-board be required each square of which in the original measures one inch to the side, the geometrical plan A, G, K, B, Study No. 2. will represent the same on a scale reduced to one sixteenth of that of the original object; sixteen of those small squares being contained in one square inch, and the whole figure A, G, K, B, being a square of two inches to the side, will be equivalent to one sixteenth part in superficial measurement of a chess-board composed of 64 square inches, shown in figures as follows ;—

Divide 64 square inches by 4 square inches, $4\,\overline{)\,64}$
$\overline{16}$ producing
4-64ths, viz. : 1-16th of the whole, or four square inches, which content is produced by multiplying the length of one side, viz :—
2 inches,
by that of the other side $\underline{2}$ do.
4 the superficial area 4 square inches.—(Eu. Book 2, Def. 1, and Prop. 1.) 64 squares each measuring one quarter of an inch to the side taken together will in superficial content amount to four square inches; and upon this scale the supposed chess-board of 64 square inches is represented by the plan A, G, K, B, in the reduced proportion of one sixteenth as previously stated.—Eu. Book, 5 ; Def. 1 ; and Prop. 7.

To draw the perspective projection C, M, N, D.

Op. 1. Divide C, D as A, B —Op. 2. Draw lines from C, 1, 2, 3, 5, 6, 7, D to the point of sight P.

Note.—D, N is the perspective representation of B, K ; and C, M that of A, G ; all lines perpendicular to the picture as B, K; A, G; E, L; &c., appear in the perspective to vanish at the same point, viz., the point of sight P ; and all lines, originally, or on the plan situate at an angle of 45 degrees to the picture (or which is the same in effect) to the line of projection 0, 0, appear in the perspective to vanish at the point of distance F ; thus the vanishing point being found for one line perpendicular to the picture as P, it is found for all lines which lie in the same direction upon the plan. Also the vanishing point (point of distance) F, being found for one line as D, F (part of which D, M is the perspective representation of B, G), the vanishing point is found for all lines which are originally orupon the plan parallelto B, G.

To find the point of distance F.

Op. 3. Take in the compasses the extent S, E (radius, distance of the eye), and set off that distance from the point of sight P, on the horizon line as at F.—Op. 4. Draw D, F, cutting the line C, P, at the point M.

To find the point M, by another method.

Op. 1. Draw a line from G, in the direction of the station point S, as far as the line of projection O, O.—Op. 2. From the point where the line last drawn meets the line of projection, let fall a perpendicular, 2, 2, to the ground line, C, D; the perpendicular so let fall, will cut the line, C, P, in the point, M, thus proving that the effect is the same in both methods used to find the point M.

The latter process might be used to find the angles of all the squares perspectively; but the following will be more expeditious.

To complete the perspective.

Op. 3. Through the point M, draw M, N, parallel to C, D, which gives on the ground level the perspective of the line G, K, eight squares distant into the picture.

The perspective diagonal, D,M, will cut the lines 1,P, 2,P, &c., at certain points; through these points draw parallels to the ground line C, D, which will give the projection, perspectively, of the squares included by the plan, A, G, K, B.

Additional examples for exercise.

Ex. 1. Remove the station point as in fig. 1, (folding plate,) and project the squares under the consequent conditions, according to the directions given in study 2.

Ex. 2. Alter the station point, &c., to the conditions of fig. 2, (folding plate,) and project the squares.

Ex. 3. Place the station point, &c., as in fig. 3, (folding plate,) and project the squares under the consequent conditions.

PLATE 3.

Fig. 1. This is a further illustration regarding the use of the point of sight in connection with a distance point, respecting measurements into the picture. Thus if C, D, represent 10 feet geometrically, D,G, will represent 10 feet perspectively; and the point R will be supposed 30 feet distant into the picture, C, D, might be divided and consequently D,G also, by means of the distance P,F, (tangent of 45 degrees equal to radius—distance of the eye from the picture, set off with the compasses from the point of sight P).

STUDY No. III.

1st.—*Plan, Elevation and Projection of a Cube measuring half an inch to the side, at, or touching the perspective plane.*

2nd.—*Plan, Elevation and Projection of a Cube half an inch distant into the picture.*

Operation 1. Draw the preparatory figure as in Study No. 2.

To draw the plans.

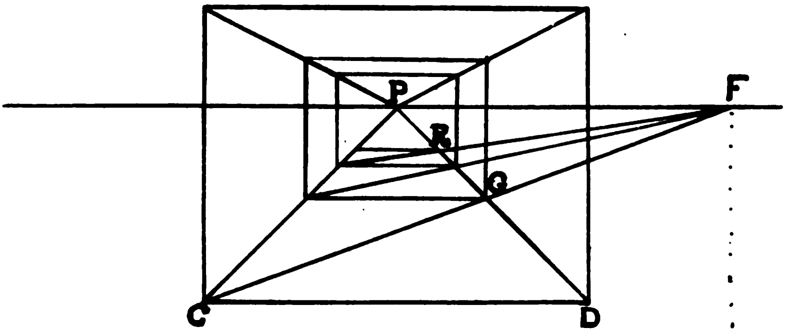
Op. 2. Find by measurement with the compasses on the line of projection O, O, how far the plans are situated to the right and left of the eye or the centre E, as from E to 1, on the right and left of E; from the points so found raise perpendiculars (as the dotted lines) on which measure the distance into the picture of the points 1, 2, 3, 4, and draw the plans. Op. 3. Set up the elevations 1 and 2 (squares equal respectively to those of the plans).

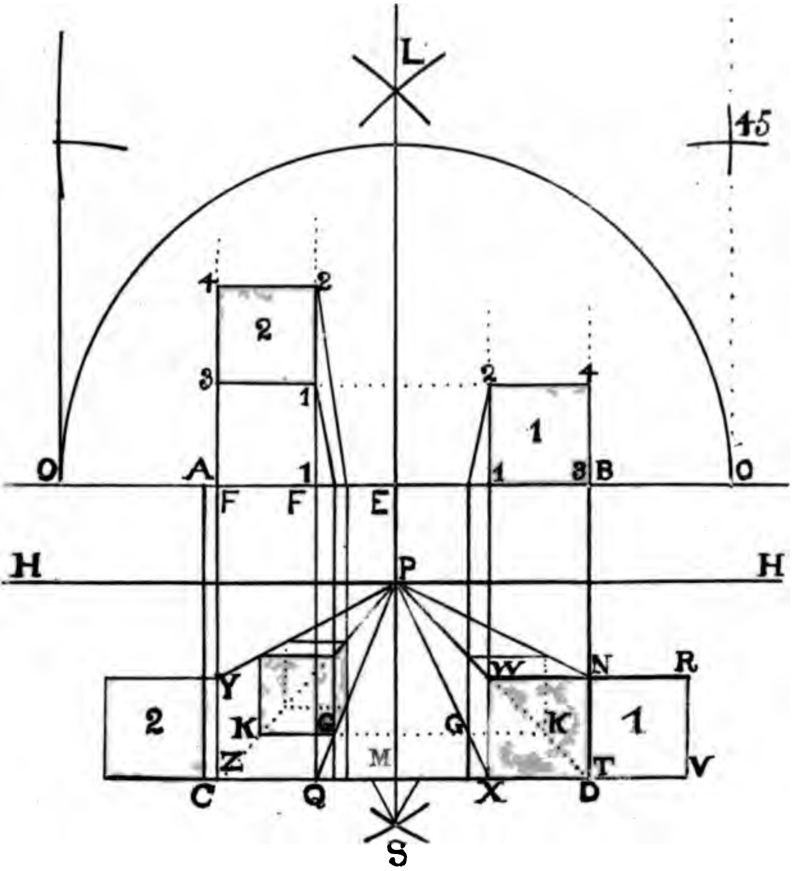
Note 1. The ground plan has reference only to the space on the horizontal plane, occupied by the base of the object to be represented.

Note 2. The elevation relates only to the height of the object as measured on the plane of the perspective. Thus in the

Pl. 3

1





case of the elevation No. 1, W, N, X, T is equal on the plane of the perspective, to N, R, T, V, which is the elevation set up beyond the limits of the picture.

To draw the perspective projection of a cube at or upon the perspective plane, by means of the plan and elevation, No. 1.

Op. 1. Let fall the perpendicular 1,X, from 1 on the line of projection O,O; 1,X, will form a line of elevation on the plane of the perspective, A,B,C,D; the line B,D, one of the boundary lines of the picture, will also form a line of elevation in this case, being in a direct line with 3,4, on the plan.—Op. 2. Draw N,W, parallel to the ground line. Thus, the near side of the cube, W,N,X,T, is drawn, or projected upon the plane of the perspective.—Op. 3. Draw T,P; X,P; W,P; N,P, lines supposed to extend from the surface of the picture to the point of sight, P, at an infinite distance upon the horizon, H,H.

To draw the visual ray.

Supposed to come from the angle 2, and through the plane of the perspective, A,B,C,D, to the eye of the spectator, situated exactly opposite to the point of sight P, at the distance, E,S, from the picture.

Op. 4. Draw a line from the angle 2 to the line of projection, O,O, and in the direction of the station point, S, (this line represents the visual ray from the angle 2) from the point where the line so drawn meets the line of projection, O,O, let fall a perpendicular to the ground line, cutting the line X,P, in the point G; draw G,K parallel to the ground line.

Note 3.—T,K, is the perspectived representation of 3, 4, on the plan; X, G, that of 1, 2; G, K, that of 2, 4; and the plan No. 1 is projected perspectively on the ground level.

Op. 5. Raise a perpendicular from K, meeting the line N,P, and from the point of contact draw a parallel to G,K, meeting the line W,P, which completes the projection No. 1.

To draw the projection of a cube, distant into the picture, by means of the plan and elevation No. 2.

To find the lines of elevation.

Op. 1. From the near angles, 3, 1, of the plan, let fall the perpendiculars, 1,Q, and 3,Z, to the ground line, C,D, the perpendiculars F,Z; F,Q; are lines of elevation to the plan No. 2, and are supposed to be at, or upon, the plane of the perspective, A,B,C,D.

To find the height of the projection on the plane of the picture.

Op. 2. Draw a line from the upper part of the elevation No 2, to the point Y. Z, Y, is the height at the perspective plane.

To project the near side of the cube.

Op. 3. Draw Z,P; Q,P; Y,P.—Op. 4. From the angle 1 of the plan, and in the direction of the station point S, draw the visual ray to the line of projection, O, O, let fall the perpendicular, passing through G, to the ground line, C, D; draw G, K; raise a perpendicular at K, to meet the line Y, P, and from the point of contact, draw a parallel to K,G.

Note 4.—Thus, the near side of the model is projected perspectively, distant half an-inch into the picture.

To complete the projection.

Op. 5. Draw the visual ray from the angle 2 of the plan in the direction of S, to the line of projection, O, O. From the point of contact let fall the perpendicular, cutting the line Q,P, to the ground line, C, D, by means of which the required points are given. Draw parallels to K, G.

Note 5.—Wherever the plans might be situated on that portion which represents the geometrical ground plane, (their sides, 1, 3—1, 3 being parallel to the line of projection, O,O), the process necessary to the production of the required projections would be similar; for example, 1st; suppose the plan No. 1 placed so that its angle 1 would be upon the point E, in that case the line E, M, would be a line of elevation, and the left side of the supposed model being in a direct line with the eye, (always opposite to the point of sight P), would consequently be invisible.

Ex. 2.—Suppose the plan 2, placed half an inch further distant from the line of projection, O,O, that is, in effect as much further distant into the picture, so that the side 3,1, were in the place of the line 4,2, in that case the projection would appear smaller than in the present instance, being situated farther from the eye; and if the plan were placed further to the left, (the eye remaining still directly opposite to P) more of the right side of the projection would come into view.

Thus their parallelism to the line of projection being maintained, the plans may be placed anywhere, according to fancy, on the part representing the geometrical ground plane; still (in representing a cube on a plane parallel to that of the horizon) there would be no necessity for alteration respecting the elevations; and the projection may be obtained either in the case of a cube at the perspective plane, or distant into the picture, by one or the other of the methods shewn.

Therefore this study involves the general question of parallel perspective.

Additional examples for exercise.

Ex. 1. Project the cubes under the conditions given in supposition, Exs. 1 and 2.

Ex. 2. Place the point of sight, &c., as in fig. 1, (folding plate,) and project the cubes from the plans and elevations, as in study 3.

Ex. 3. Project the same, subject to the conditions of fig. 2, (folding plate.)

Ex. 4. Project those subject to the conditions of fig. 3, (folding plate).

STUDY No. IV.—Plate 4.

ANGULAR PERSPECTIVE.—CUBE AT ANGLE OF 45 DEGREES.

Plan, Elevation, and projection of a cube, the sides thereof making angles of 45 degrees with the perspective plane, the near angle at the picture.

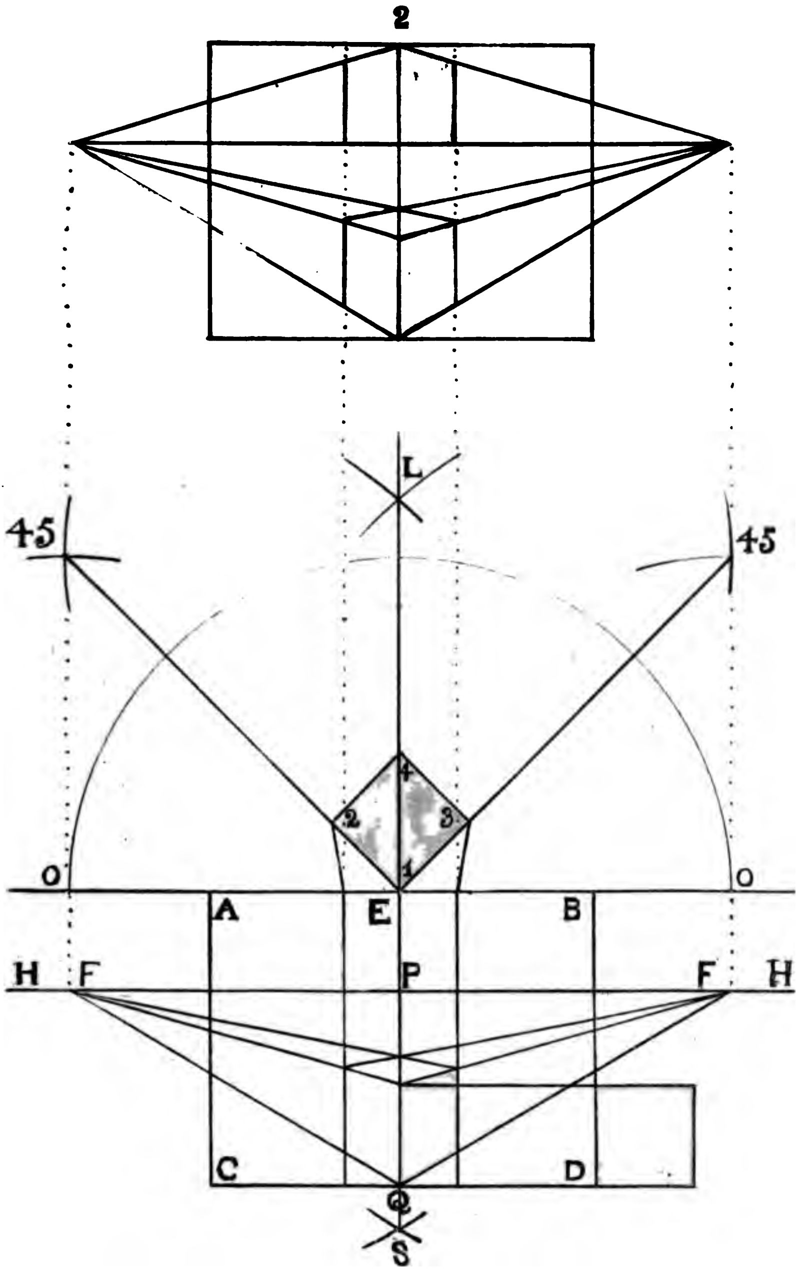
Note 1. In this study a remarkable variation occurs respecting the position of the plan, neither of the sides being parallel to the plane of the perspective, but each situate at an angle of 45 degrees thereto, under this supposition a spectator standing at S, which is directly opposite to the angle 1 of the plan, would see of the two visible sides respectively an equal proportion; the line of the horizon, which gives the height of the eye, being as in the previous studies considerably above the level of the projected cubic figure, the upper surface thereof is well seen; the point of sight is as previously at P, but is not in this case a vanishing point: the receding lines of the projected figure now vanishing at one or the other of the points of distance, F, F, which points are equidistant from the centre of the picture (point of sight P,) in every case, and the lines on the plan E, 45 ; E, 45 ; or lines parallel to either of those, would in the picture (viz. perspectively) appear to vanish at one or the other of the said points of distance. It is therefore to be understood that whenever a line on the plan is drawn at an angle of 45 degrees to the line of projection, O, O, (viz. in effect to the picture) its vanishing point on the horizon may invariably be found by the rule applied in this case.

Op. 1. Draw the preparatory figure as previously.

To draw the plan.

Op. 2. Take in the compasses the distance S, E, (radius), and with one foot in O, both on the right and left, find on the tangent lines the points 45, 45. Draw E, 45,—E, 45 ; thus the lines

Pl. 4.



necessary to determine the angle which the plan makes with the picture are obtained.—Op. 3. Take in the compasses half an inch, and with one foot at E find the points 2, and 3; next with one foot at 2, or 3, find the point 4, and draw the plan.

To draw the elevation.

Op. 4. Make a square equal to that of the plan as in the example.

To find the line of elevation.

The near angle of the plan touches the picture in the point E, and being thus centrally situated at the picture, the vertical line E, Q, will serve for the line of elevation upon the perspective plane.

To find the vanishing points.

Note 2.—In parallel perspective only two points are used, namely, the point of sight (vanishing point), and the point of distance (a measuring point), in angular perspective there must be found a separate vanishing point for each variety of angle which is made by the plan with the perspective plane; which in any case may be found by means of a simple rule practically exhibited in these studies. In this case (angle 45 degrees.)

Op. 5. Take in the compasses the extent 0, 45—the tangent to the angle which the plan makes with the picture;—equal to E,S,—distance of the eye, (radius,) and set it it off on the line of the horizon, H, H, from the point of sight P, both ways, viz., to the points F, and F.

To project the cube perspectively.

Op. 6. Draw Q, F; Q, F.—Op. 7. Continue the upper line of the elevation to the line of elevation, E, Q, and from the point of contact, draw to the points of distance, F, F; thus the height of the projection into the picture is given, diminishing perspectively.

To find the perspective sides of the cube (their apparent width on the plane of the perspective.

Op. 8. Draw a line from the angle 2 of the plan, in the direction

of the station point, S, as far as the line of projection, O,O; from the point thus found on the line of projection, let fall a perpendicular to the ground line, C,D; repeat the operation from the point 3 on the plan, those perpendiculars respectively will cut the lines Q, F; Q, F, giving the projected near sides of the figure, on the right and left of the vertical line, E, Q.

To complete the projection.

Op. 9. From the intersections of those perpendiculars with the upper lines of the projected sides of the cube, draw to F, and F.

Note 3.—Had perpendiculars been let fall from the points O, O, to the horizon at F, and F, as shown by the dotted lines in the example, the vanishing points might have been found thereby, P,F; E;O;—E,S; and 0, 45, being equal, each to each.

Note 4.—Were the plan removed so that the angle 1 might touch the line of projection any where between A, and B, (still maintaining the angle 45), the method of projection would be similar; but in such case a line of elevation distinct from E, Q, would be required, similar to that in Study, No. 5.

Example 2.

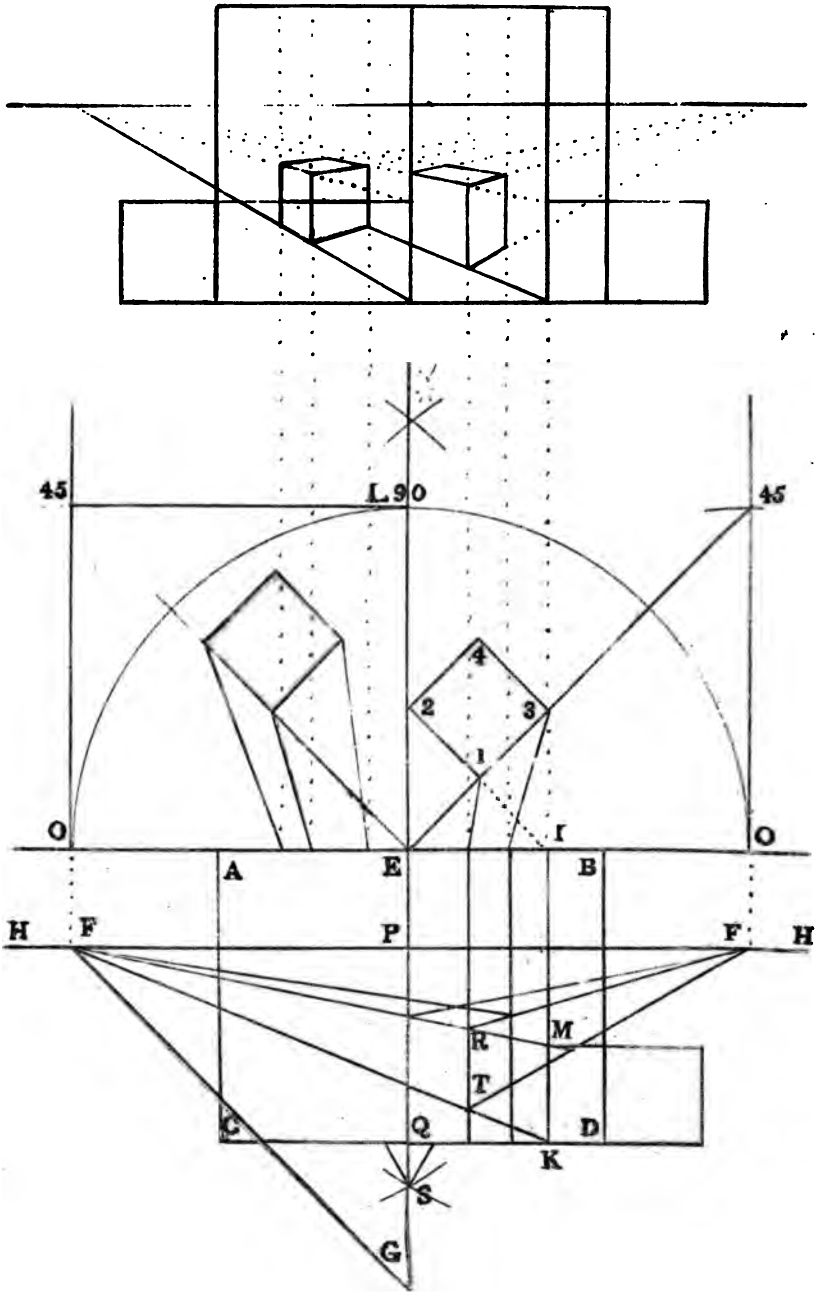
The projections in this case are given by means of measurements copied from Study, No. 4; one representing a cube whose lower surface being on the level of the spectator's eye, is consequently invisible. Thus three projections are given in connexion with one plan only.

A mechanical method of finding vanishing points.

See fig. 4 of the folding plate.—The edge of a parallel ruler is placed in connection with the plan as shewn at A, brought backward to the position B, a line, as S, O, is drawn from the station point S, to the line of projection, and a line, as O, F, let fall to the horizon.—In this case, (angle 45) E, S, (distance of the eye, radius,) is equal to P, F, (tangent 45°).

PL. 5:

2



STUDY No. V.—Plate 5.

Plan, elevation, and projection of a cube, situate to the right of the eye, at an angle of 45 degrees to the plane of the perspective; and distant into the picture half-an-inch, upon a line inclined at an angle of 45 degrees to the picture.

Op. Draw the preparatory figure (Study 2, Op. 1.)

To find the near angle of the plan, and to draw the same; also the elevation.

Op. 1. Draw E, 45;—E, 45.—Op. 2 Take in the compasses, the extent, half-an-inch, and set it off on the line E, 45, from E, to 1.—Op. 3. Measure half-an-inch from 1, viz., 1, 3.—Op. 4. Raise perpendiculars at 1, and 3.—Op. 5. Set off on those the sides 1, 2; and 3, 4.—Op. 6. Draw the square 1, 2, 3, 4.—Op. 7. Draw the elevation, a square equal to that of the plan, as at D.

Perspective projection.—To find a line of elevation upon the plane of the perspective, distinct from the vertical line, E, Q.

Op. 1. Produce the side, 2, 1, of the plan to the line of projection, O, O, as shown by the dotted line.—Op. 2. From the point I, let fall a perpendicular to the ground line, which perpendicular will be the line of elevation, I, K.

Rule for finding the vanishing point of a line inclined at any given angle to the picture.

Set off on the horizon line from the point of sight, the tangent of the angle which the line makes with the perpendicular on the other hand.

Practical application in this instance (angle 45).

Tangent to the angle, O, 45;—the line, E, 45;—perpendicular on the one hand, E, L;—On the other, E, O (as in Study 4).—Op. Take in the compasses the tangent to the angle L, E, 45,—viz., the extent L, 45—or O, 45 (those being equal in this case), and set off that distance on the horizon line, H, H, to the right and left of the point of sight, P, viz., to F, and F; (points of distance).

Observations, &c., intended to elucidate the theory of vanishing points, 1st, (geometrically).

E, S, is the distance of the eye from the picture, equal to the radius, E, O, of the semicircle, O, 90, O: but the height of the eye upon the perspective plane A, B, C, D, being determined by the position of the horizontal line H, H, and the point of sight, P, by the intersection of the vertical line, E, Q, therewith;—if therefore the eye be placed in accordance with this study, it will be directly opposite to P; and the distance of the eye from the picture being equal to E, S,—P, G, equal to E, S, will be the distance of the eye from the picture, directly opposite to P, (when the eye is on the level of H, H, as in this case). Now P, G, (the distance of the eye in this instance) being made radius, viz., equal to E, O, is also equal to 0, 45, which is the tangent of the angle of 45 degrees to the radius E, O, and the line E, 45, is a line inclined at an angle of 45 degrees to the picture;—or which is in effect the same, to the line of projection 0, 0

2ndly. Practical Illustration,—perspectively.

Place the paper triangle, two sides of which are cut through in the plate, in a perpendicular position to the plane of the perspective, A, B, C, D, and it may be perceived that supposing the eye of the spectator to be placed at G,—if G, P, the distance of the eye from the picture, be made radius, P, F, will be the tangent to the angle of 45 degrees to that radius, (being equal thereto) on the plane of the picture, or on its supposed continuation, and the line

G, F, being a line inclined at an angle of 45 degrees to G, P, will meet or cut the perspective plane, or its supposed continuation, at the point F,—and the tangent P, F, would to an eye placed at G, apparently measure on the plane of the projection, all tangents to the angle P, G, F, however far the radius might be supposed to extend beyond, or behind, the perspective plane A, B, C, D ; and the principle applies in the case of any angle and tangent given. See the subsequent examples, and Fig. 5 (folding plate).

To find the near angle, perspectively.

Op. 1. Draw K, F, (this line is the perspective projection of the dotted line on the plan, and its continuation infinitely).—Op. 2. From the angle 1 of the plan, and in the direction of S, draw to the line of projection, O, O; from the point thus found on the line of projection let fall a perpendicular, cutting the line K, F, at a certain point—the perspective position of the angle 1.—Op. 3. From the point thus found, draw to the point of distance, F, on the right; (this line is the perspective projection of the line, 1, 3) and its continuation infinitely).

To find the height of the projection at the picture, on the line of elevation.

Op. Continue the upper line of the elevation (the square at D,) to the line of elevation I, K.—K, M, is the height required.

To find the height perspectively, viz., distant into the picture.

Op. 1. Draw M, F, thus finding the point R,—T, R, is the height required.—Op. 2. Draw R, F ;—R, F.

To project the visible sides of the cube.

Op. 1. Draw the visual rays from the angles 2, and 3, of the plan, in the direction of the station point S, to the line of projection, O, O.—Op. 2. From the points thus found on the line of projection let fall perpendiculars, which will give the required sides,—also two points of intersection, from which lines to F, and F, will complete the projection.

NOTE.—The visual ray from the angle 2 upon the plan, being in a direct line with the eye, coincides in this instance with, or is supposed to pass through a certain point on the vertical line, E, Q, the lower angle in the projection being given on the line E, Q, by the intersection of K, F, therewith, and the upper angle by that of M, F.

NOTE 2.—In consequence of removal to the right of the eye, more of the left side of the projected figure is seen; whilst the right side thereof retires proportionally, viz., it is seen under a smaller apparent angle on the perspective plane, A, B, C, D, than that of the left side; also in consequence of its distance into the picture the whole figure measures less on the perspective plane than in the case of Study 4.

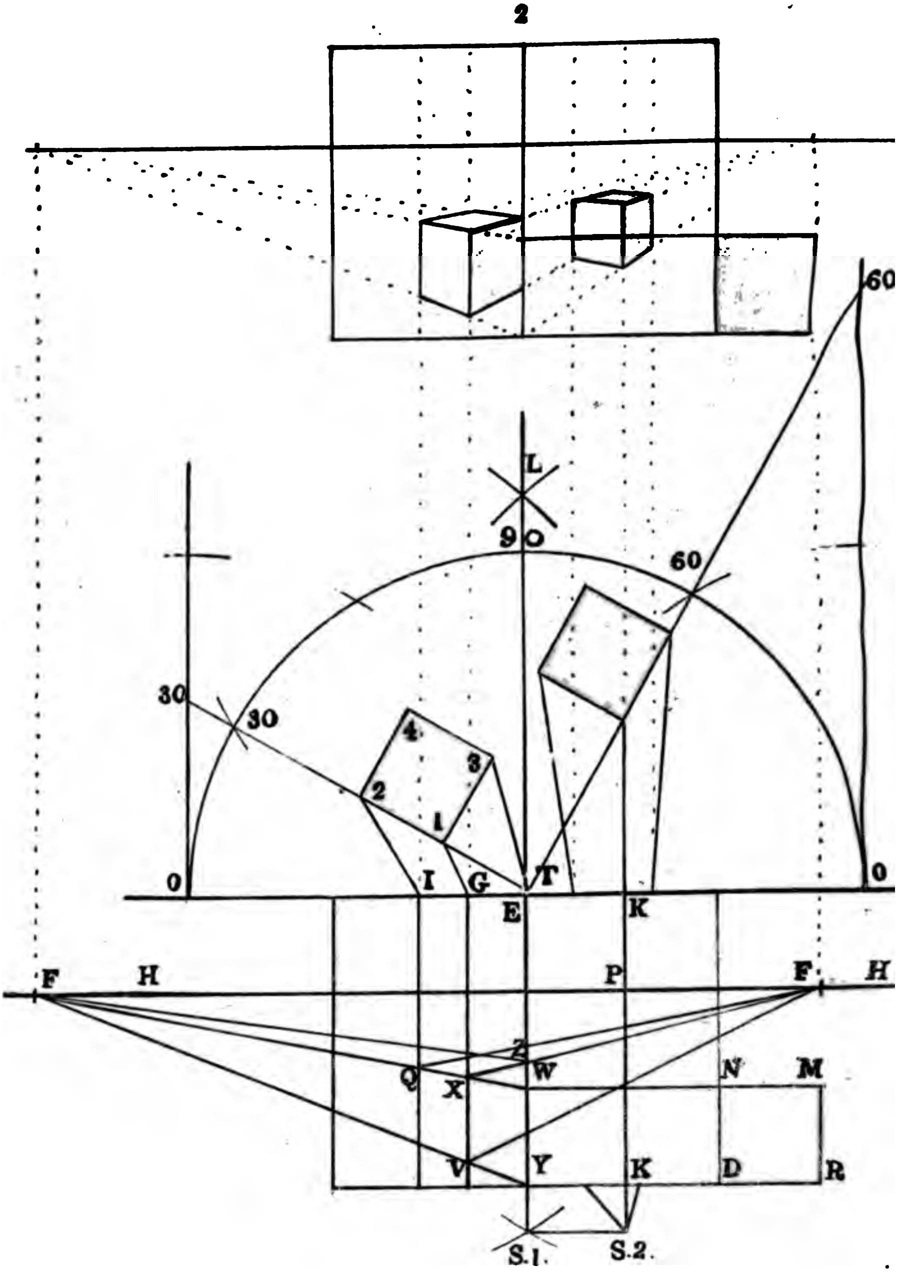
EXAMPLE 2 gives a projected cube in addition, and is copied in part from Study 5.

Experiment.—All other conditions remaining as before, elevate or depress the horizontal line H, H. Project the figures according to the directions given, in which case, more or less of the upper surfaces will be visible in the perspective.

Measurement of angles upon the plane of the perspective.

Fig. 5 (folding plate), H, H, represents the horizon at an infinite distance, and A, B, a section of the perspective plane. G, P, is distance of the eye therefrom (radius in this instance;) P, F, is tangent at the plane, to the angle of 45 degrees, F, G, P,; which angle also it measures to an infinite extent, apparently, upon the plane of the perspective, A, B. H, H, upon the horizon, is tangent to the angle of 45 degrees (to radius G, H.) The tangent, P, T, to the angle of 30 degrees, T, G, P, on the plane of the perspective, measures apparently, and to an infinite extent the angle as in the case of T, G, P, or R, G, H.—In like manner, the tangent to any angle set off upon the plane of the perspective from the point of sight, apparently measures that particular angle upon that plane.

PL.6.



STUDY No. VI.—Plate 6

Plan, elevation and projection of a Cube, dimension half-an-inch to the side. Angular position, two sides at angles of 30 *degrees to the plane of the perspective; the remaining sides consequently at angles of* 60 *degrees to the same. Lateral position, to the left of the eye. Distance into the picture, half-an-inch obliquely, upon a line inclined thereto, at an angle of* 30 *degrees.*

In this study two important elementary operations are exhibited in connexion, viz., 1*st*, alteration of the angles made with the picture by the sides of the plan; 2*ndly*, change of situation respecting the observer's eye, which in this instance is supposed to be directly opposite to P (point of sight in this case), consequently K, K, represents the vertical line; S, 2, is now the station point.

Construction.—Op. Draw the preparatory figure as in study 2.—Op. 2, Remove the station point to S 2, and draw the vertical line, K, K.

To draw the angle, 30, *E,* 60.

Op. 1. Take in the compasses the extent S,2, K, K (radius), and with one foot at O on the right hand, find on the arch the point 60.—Op. 2. Draw the line E, 60, 60.—Op. 3. With the same extent, and one foot at 90, find on the arch the point 30.—Op. 4. Draw E, 30, 30.

Near angle of the plan—To find the distance in, geometrically.

Op. Measure half-an-inch from E, viz., to 1, the position of the near angle.

To draw the plan.

Op. 1. Place the parallel ruler co-incident with the line E, 60. —Op. 2. Move the edge of the ruler to the point 1.—Op. 3. Draw a perpendicular to the line E, 30, from the point 1.—Op. 4. Take in the compasses half-an-inch, and with one foot at 1, find the points 2 and 3.—Op. 5. With one foot at 2, and next at 3, find the point 4. Op. 6. Draw the plan, 1, 2, 3, 4.

To find the line of elevation.

The side 2, 1, of the plan coinciding with the line 2, 1, E.—E, Y, will be the line of elevation in this case.

To find the vanishing point for the line E, 60.

Op. Take from the tangent line on the left, the extent O 30, and set it off on the horizontal line H, H, to the right, from the point of sight P, viz., the distance P. F. (See the general rule, and illustrative example, Study 5.

To find the vanishing point for the line E, 30.

Op. Take from the tangent line on the right, the extent O, 60, and set it off on the horizontal line H, H, to the left, from the point of sight P, viz., the distance P. F, on the left hand. (See rule, &c., as above.)

Note.—Thus, perspectively, the lesser tangent applies to the greater angle, and the greater tangent to the lesser angle.

To find the near angle (perspectively).

Op, 1. From Y at the ground line, draw to F on the left.—Op 2. From the angle 1 of the plan, and in the direction of S, 2, draw 1, G, to the line of projection.—Op. 3. Let fall the perpendicular G, V, cutting Y, F, in the point V.—Op, 4. Draw from V, to F, on the right; V, is the required angle.

To find the height of the projection.

Op. 1. Draw the elevation N, M, R, D, (a square equal to that of the plan).—Op. 2. Produce the upper line M, N, to W, on the line of elevation.—Op 3. Draw W, F; and X, F.

To project the visible sides of the cube.

Op. 1. From the angles 2, and 3, of the plan, and in the direction of the station point, S, 2, draw to the line of projection, O, O. Op. 2. From the points of contact I, and T, let fall perpendiculars to the ground line C, D; the perpendiculars so let fall, cut the lines V. F; V, F; X, F; X, F; giving thus, perspectively, the visible, vertical sides of the cube.

Op. 3. Draw Z, F; and Q, F, which complete the projection.

Note.—If the side 2, 1, of the plan were so placed as to make a very small angle with the line of projection 0, 0, a very long tangent would be required to find the corresponding vanishing point; therefore it is not advisable, as a matter of choice, to project plans or objects whose sides originally make small angles with the picture; respecting rectangular plans generally, angles of 45; 30, and 60; 40, and 50; 20, and 70 degrees will suffice.

To project a circle perspectively.

See fig. 6th (folding plate). Enclose the circle by a square (Euclid, book 4, prop. 7). The square being subject to the conditions given in any of the previous examples, and the straight lines of the geometrical figure 6 being projected perspectively, 8 points are found, through which the circle may be drawn perspectively by the hand, subordinate to the conditions of the square.

STUDY No. VII.— Plate 7.

Plan, elevation and projection of a cube, ; side of the plan, half-an-inch ; angles, with the plane of the perspective, 40 *and* 50 *degrees; lateral position, to the right of the eye; distance into the picture (measured obliquely), half-an-inch.*

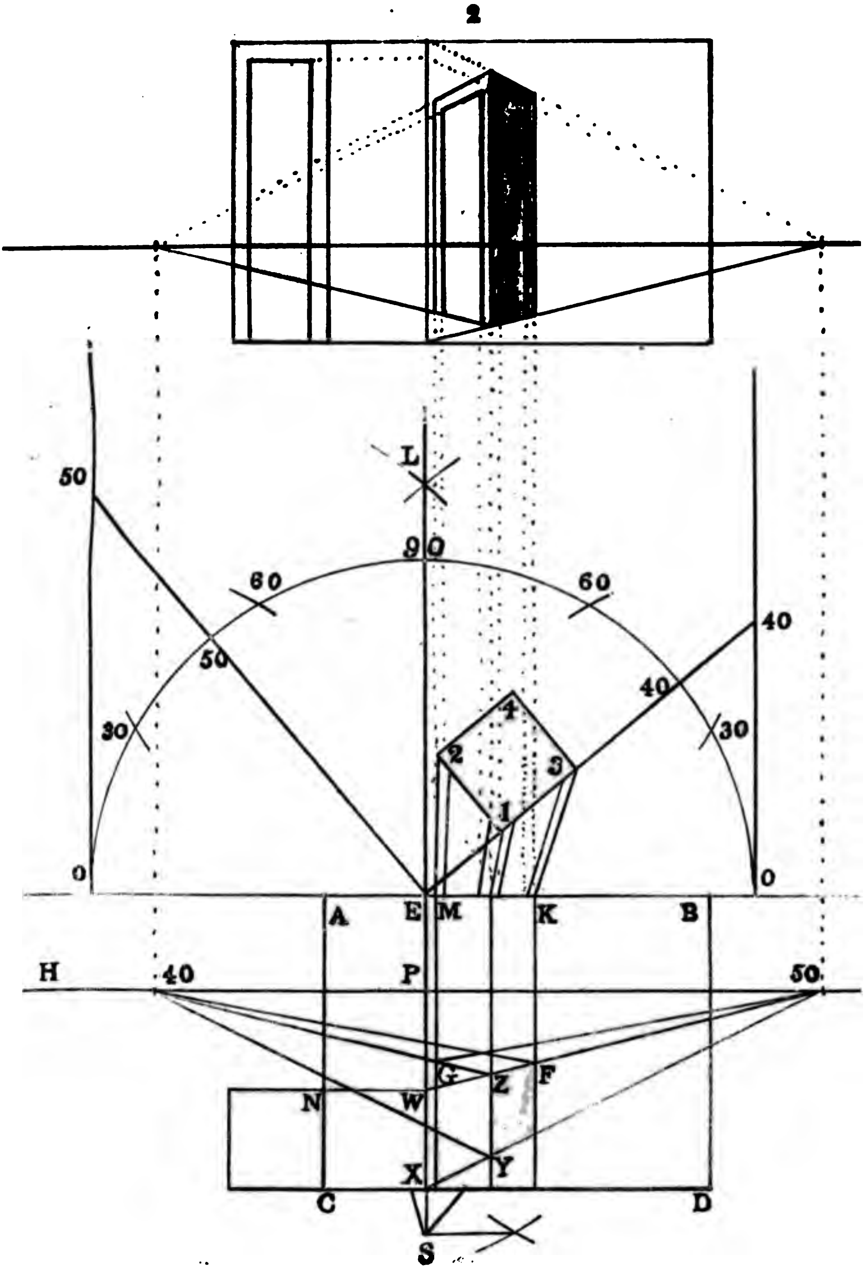
In this example, the angles made with the picture by the sides of the plan are again varied, and the station point removed to the left of the centre.

Construction.—Op. 1. Draw the line of projection, O, O, the plane of the perspective, A, B, C, D,—its visual angle,—and the line of the horizon, H, H, as previously.—Op. 2. Remove the station point to S, draw the perpendicular, S, E, L; also the semicircle, 0, 90, 0, to radius, S, E.—Op. 3. Set up the tangent lines from O, and O.

To draw the right angle, 50, *E,* 40*; also to find tangents to the angles* 40, *and* 50.

Op. 1. Take in the compasses the extent, E, S, (radius). Set off that extent upon the arch from O,—both on the right and left, to find the points 60, 60.—Op. 2. Set off the same extent from 90, to find the points 30, 30, upon the arch.—Op. 3. Take in the compasses one-third part of the extent, 0, 30. Set off that third part upwards from 30 on the arch, thus finding the point, 40, thereon.—Op. 4. Draw the line E, 40, through 40 on the arch to the tangent line on that side.—Op. 5. Set off one-third part of 0, 30, downward upon the arch from 60 on the left, to find the point 50, on the arch.—Op. 6. Draw the line E, 50, from E, through the point 50 on the arch to the tangent line on that side.—0, 50, thereon is the tangent to the angle of 50 degrees,—on the right,—0, 40, upon the tangent line is the tangent to the angle of 40 degrees; both to radius S, E.

PL. 7.



To find the position of, and to draw the plan.

Op. 1. Measure half-an-inch from E on the line E, 40, viz., to 1, the near angle of the plan.—Op. 2. Place the parallel ruler coincident with the line E, 50.—Op. 3. Advance the edge to the point 1, and draw the perpendicular 1, 2.—Op. 3. Set off on the line E, 40, the half-inch 1, 3, and raise at 3 the perpendicular 3, 4.—Op. 4. Draw the plan 1, 2, 3, 4.

Note.—The side 3, 1, of the plan produced meets the perspective plane at the point E:—thus, the vertical line in this case coincides with the line of elevation, viz., E, X, (a line of elevation distinct from E, X, may be obtained, if required, as in Study 5, by producing the side 2, 1, to the line of projection.

To obtain the vanishing points.

Op. 1. From the tangent line on the right, take the extent, 0, 40, (tangent of 40 degrees to radius S, E,) and set the same off upon the horizon to the left, from the point of sight P, viz., the extent, P, 40.—Op 2. From the tangent line on the left take the extent, 0, 50, and set off the same on the horizon line to the right from P, viz., the extent, P, 50.

To obtain the height of the projection at the picture.

Op. 1. Draw the elevation, N, C, a square equal to that of the plan.

Op. 2. From the elevation at N, draw N, W, to the line of elevation, E, X,—X, W, is the height at the picture.

To obtain the near angles perspectively.

Op. 1. Draw X, 50.—Op. 2. Draw a line from the angle 1, in the direction of the station point S, to the line of projection, O, O; from the point of contact let fall the perpendicular Z, Y, cutting X, 50, at Y.—Op. 3. Draw Y, 40, W, 50, and Z, 40.

To complete the projection.

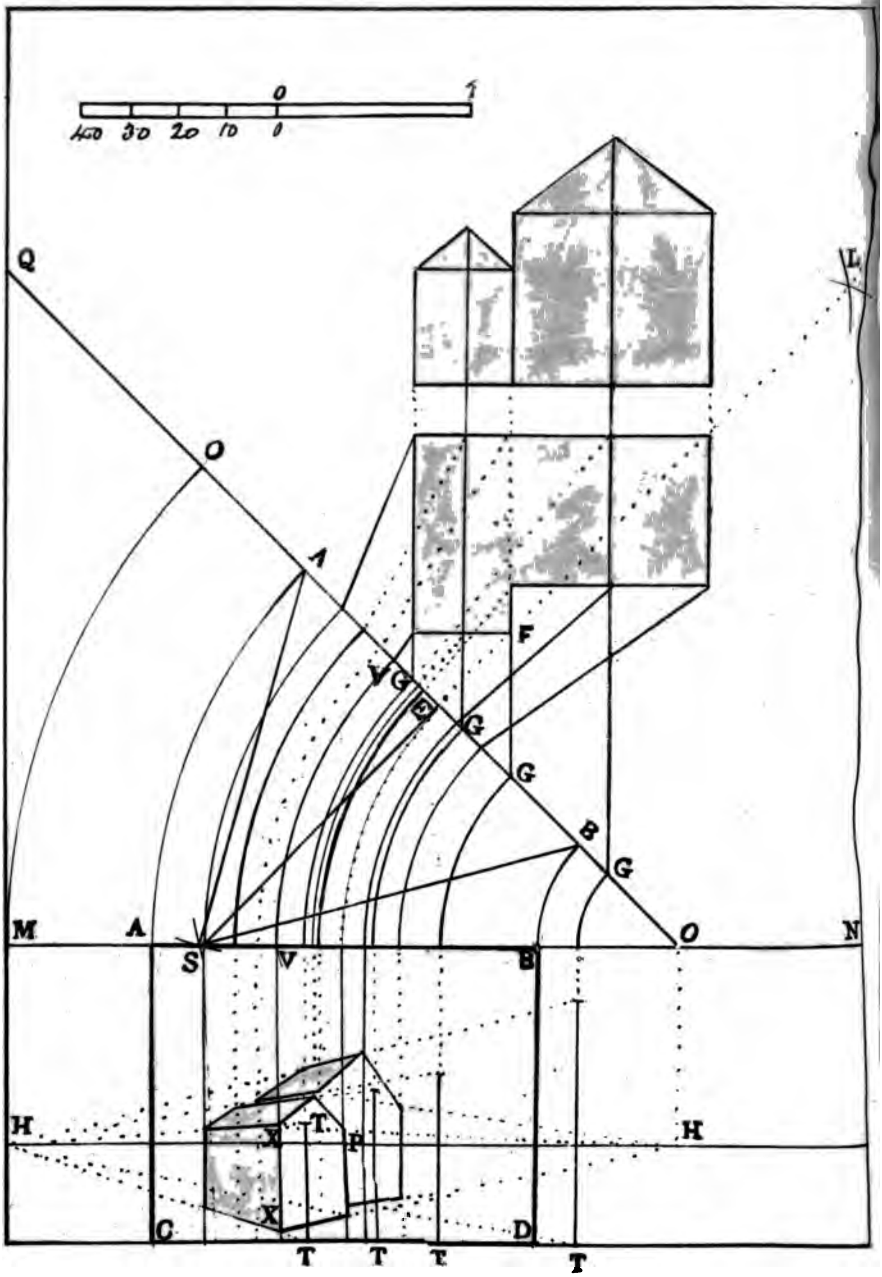
Op. 1. Draw visual rays from the angles 2 and 3 of the plan in the direction of the station point S.—Op. 2. From the points of contact, M, K, let fall perpendiculars cutting the lines Z, 40,—Z, 50, at G, and F.—Op. 3. Draw F, 40, and G, 50.

Example 2. In this case the elevation is increased to three times the height of the former one, and by means of the projection the representation in outline of a building is given; the plan, &c., is taken from Study 7;—the dotted lines show the mode of operation.

Note 1. Were the height of the elevation N, C,—Study 7,—half-an-inch,—supposed to represent 6 feet, the projection in Ex. 2 would represent a tower of 18 feet in height; the base of which in the original would measure 36 square feet; the remaining conditions might consequently be estimated by the same scale.

Note 2. It is not difficult to perceive that by the means employed in the foregoing Studies, the side of a square might be varied, or turned on the plan, from the parallel A, E, through all the various angles measured by the arc of the quadrant, to the perpendicular E, L; and by taking the required vanishing points from a line of tangents in the manner herein demonstrated and explained,—vanishing points might be found to all angles of sufficient magnitude to admit the finding of the tangents corresponding thereto.

PL. 8.



STUDY No. VIII.—PLATE VIII.

Plan, elevation, and projection of a building—distance into the picture* 20 *feet,—angles thereof with the picture* 45 *degrees. Scale one-fortieth part of an inch to the foot.

In this study the horizontal line is placed at half-an-inch, (representing 20 feet) above the ground level, the surface A, B, C, D, on which the picture is drawn, in this instance represents a plane measuring 80 feet by 60, supposed to be seen under a visual angle of 60 degrees, in which case the distance of the eye E, S, will represent about 70 feet.

CONSTRUCTION.—OP 1. Draw the line O, O, indefinitely.—OP. 2. Assume a point as E, set off each way from E, one inch, thus obtaining the width of the picture, A, B.—OP. 3. Make on A, B, an equilateral triangle to find the station point, S, and to determine the visual angle, A, S, B.—OP. 4. Set off the radius S, E, from E, to O, and O, draw M, N, through O, and S, and the perpendicular, M, Q.—OP. 5. With the extent, O, O, in the compasses, and with one foot at O, both at the right and left, find the intersection at L. Bisect O, O, by drawing S, L.—OP. 6. Set off on E, L, from E, half-an-inch, to find the position of the angle F.—OP. 7. Draw the plan, also the elevation parallel to M, Q; M, N.—OP. 8. Let fall the lines G, G, G, G, to the line O, O, and with one foot at O, on the right transfer the points G, G, G, G, to the line of projection, M, N, also the vanishing points, O, and O, to the horizon at H, and H.—OP. 9. Let fall perpendiculars, T, T, T, T, to the ground line C, D, which perpendiculars will be lines of elevation.—OP. 10. Draw the visual rays from the visible angles of the plan in the direction of S, to the line O, O, and by means of the compasses transfer those to the line of projection M, N, letting fall perpendiculars as before.

—Op. 11. From the elevation take the heights and set those off on the lines T, T, T, T.—Op. 12. From the points T, T, on the left draw to the vanishing point H on the left, the perpendicular from V will give the near angle X, X.—Op. 13. To H on the right draw X, H; X, H, and complete the projection by the same method.

Note.—This method may be used in other cases than that of the right angle, as here given, by increasing or diminishing the angle Q, M, N, or the plane of the picture, plan, and elevation to a larger scale, as that of Study XIII., which is increased four-fold, with doors, windows, &c., first drawn, and the remainder added, or with only tangents to the radius S, F, set off from P (point of sight) to find the vanishing points; or those may be found mechanically by the method of fig. 4 (folding plate), See page 16.

Planning from Natural Objects.

In the first instance the actual measurements of the original objects must be known, or assumed.—Secondly. They must be reduced to any convenient scale by calculation, and drawn agreeably to that scale. The height of a man is one of the principal objects for consideration in regard to plans of buildings (see Study VII.); in this example (Study VIII.) 5-40th parts of an inch represent the height of a man 5 feet in stature.—The line of the horizon, H, H, being half-an-inch from the ground level, is supposed to be 20 feet above the ground line, C, D, and the eye of the spectator being always on the level of the horizontal line, consequently his feet will be supposed to be about 15 feet above the level of the ground; as, for instance, on the floor of a building at the said elevation.—E, S, distance of the eye is measured by the scale of the plan.

STUDY IX.—(FOLDING PLATE.)

Projection of shadows, when the sun's rays are parallel to the perspective plane.

Op. 1. Draw the picture, &c. to the conditions of fig. 1. Op. 2. Draw the plan, elevation, and projection, according to the method of No. 2, Study 3, p. 10.

For the shadow.

Op. 1. Draw the plan of the shadow, as in the example; in this instance, the projection of the shadow is a square equal to that of the plan, which would be the case when the sun is at the elevation 45 degrees above the horizon; the length of the shadow on the ground plane being, in such case, equal to the height of the object. Op. 2. Produce the lower lines of the cube which are parallel to the picture, indefinitely, on the right hand. Op. 3. Draw visual rays from the angles of the shadow, as in the example, to the line of projection in the direction of the station point S. Op. 4. Let fall perpendiculars to the ground line as usual; those perpendiculars cut the lines produced in Op. 2. Op. 5. Join the points of intersection, to obtain the perspective projection of the shadow.

STUDY X.—(Folding Plate.)

When the sun is distant into the picture.

Op. 1. Draw the plan, elevation, and projection, as in the previous example.

For the shadow.

Op. 1. Determine the place of the sun as at A, and let fall a perpendicular therefrom to the horizon. Op. 2. From the point thus found thereon draw lines indefinitely through the angles of the projection on the ground plane as at B, and C. Op. 3. Draw lines from the sun at A through the upper near angles of the projection, until those respectively intersect the lines drawn in Op. 2. Op. 4. Join the points of intersection by a line.

STUDY XI.—(FOLDING PLATE.)

Shadow from a lamp or candle.

Op. 1. Draw the projection as previously.

For the shadow.

Op. 1. Determine the position of the luminary, and let fall a perpendicular therefrom to the ground plane. Op. 2. From the point thus found on that plane, draw lines through the lower angles of the projection. Op. 3. From the centre of the light, draw lines through the upper angles of the projection, produced until those respectively intersect the lines drawn by Op. 2. Op. 4. Join the points of intersection by lines, as in the example.

STUDY XII.—(Folding Plate.)

Plan, elevation, and projection of a cube, length of its side half an inch; the near angle at the picture. Angles made by its sides therewith, of 30 *and* 60 *degrees. Angle made with the picture by the shadow, one of* 30 *degrees. The sun's position in front of the picture, shining thereon obliquely, and its elevation above the horizon* 45 *degrees (the length of the shadow on the ground plane being equal to the height of the object).*

Op. 1. Draw the plan, elevation, and projection of the cube by the ordinary method.

For the shadow (geometrically).

Op. 1. Draw a line from the near angle of the plan through 30 on the arch, and lines parallel to the same from the remaining shaded angles of the plan.—Op. 2. Set off the height of the cube on those lines from the respective angles.—Op. 3. Join the points thus found by lines to obtain the outline of the shadow on the plan.

For the shadow (perspectively).

Op. 1. Find the vanishing point of the shadow V, by setting off the tangent to the angle of 60 degrees on the horizon, from the point of sight P, to the left hand, or mechanically (whatever be the degree of the angle), by the method of fig. 4. See page 16.—Op. 2. Draw lines from the shaded angles on the ground plane of the projection, to the vanishing point V.—Op. 3. Draw visual rays from the angles of the shadow on the plan in the direction of S, to the line of projection.—Op. 4. Let fall perpendiculars from the points thus found to the ground line: these give points of intersection with the lines drawn to V.—Op. 5. Join the points so found by lines, to obtain the outline of the shadow perspectively.

STUDY XIII.—(Folding Plate.)

In this instance the scale of the picture is increased fourfold (geometrically) the plans and elevations remaining to the same scale as previously, and in consequence of the plans being so placed that their lines of elevation in certain cases coincide at the line of projection, 8 projections are given in connection with 3 lines of elevation only.

Op. 1. Draw the plane of the perspective to the dimensions 4 inches by 3.

Op, 2. Make the visual angle one of 60 degrees, (direct) place the horizontal line at two inches above the ground level, and the vertical line central thereupon.—Op. 3. Draw the plans at the required angles.—Op. 4. Find the lines of elevation upon the plane of the perspective.—Op. 5. Draw the visual rays in the direction of the station point S, to the line of projection.—Op. 6. From the points thus found on the line of projection, let fall perpendiculars to the ground line.—Op. 7. Set off from the point of sight P, the respective tangents to find the vanishing points. Op. 8. From the lines of elevation at the ground line, draw to the vanishing points respectively.—Op. 9. Transfer the heights from the elevations to the respective lines of elevation on the perspective plane, and draw to the vanishing points, or as far only as may be required in the case of each projection (determined by the intervals between the perpendiculars let fall from the visual rays.—Op. 10. Complete the outline of each projection by connecting the points found in the usual manner—the shadows may be obtained by the method of Study IX, X, XI, or XII.